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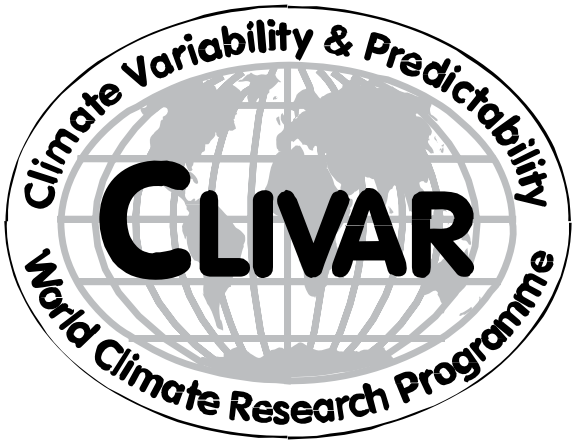

Report of the 7th Session of the Asian-Australian Monsoon Panel

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CLIVAR is a component of the World Climate Research Programme (WCRP). WCRP is sponsored by the World Meterorological Organisation, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO. The scientific planning and development of CLIVAR is under the guidance of the JSC Scientific Steering Group for CLIVAR assisted by the CLIVAR International Project Office. The Joint Scientific Committee (JSC) is the main body of WMO-ICSU-IOC formulating overall WCRP scientific concepts.

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Action 3: ICPO to work with panel members and GEWEX to target appropriate agencies so as to realise a catalogue the present long term atmospheric observing system across the AAM region as basis for identifying key stations and gaps in the network)

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Action 6: Kang, Slingo, Hendon and McCreary to take forward interactions with WGSIP/TFSP on AAMP's role in regional analysis of the TFSP Prediction Experiment outputs, and in particular to prepare a white paper for consideration by the panel.

Action 7: The panel to identify a range of suitable metrics relating to the AAM for application to the outputs of the TFSP Experiment (All)

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Action 9: The panel to explore the CDC intraseasonal oscillation intercomparison activity, potentially with a role to organise a set of metrics for such comparisons (Wang, Kang)

Action 10: ICPO to provide a link from the AAMP webpage to the CDC intraseasonal oscillation intercomparison as and when one is in place.

Action 11: R Lueng and others to consider how best to approach the development of an overall AAMP regional modelling approach.

Action 12: The Panel identified ENSO-monsoon connections, including decadal variability issues including decadal variability and studies of the MJO as key areas of future interaction between AAMP and the CLIVAR Pacific Panel. This should be taken forward in the first instance by the co-chairs of AAMP and the Chair of the Pacific Panel (Dr Axel Timmermann).

Action 13: Bin Wang to discuss collaboration on the EA-WNP area with the Pacific Panel chair, in particular with emphasis on assessment of coupled model simulation of the EA-WNP monsoon with an initial attack on systematic model errors.

Action 14: Clarify the available date for the Indian Ocean issue of CLIVAR Exchanges (Cattle)

Action 15: Clarify the routes and nature of reporting of IOP activities (Cattle)

Action 16: IOP and AAMP chairs in liaison with the ICPO to communicate to the SSG recommending a broader science mandate for IOP.

Action 17: The Panel needs to revisit the present version of the prospectus and update it in the light of the expanded remit of the panel set down by the CLIVAR AAMP Task Force(see below).

1. Introduction

The 7th session of the CLIVAR Asian-Australian Monsoon Panel (AAMP) was held at the University of Irvine, California, USA from the 18-19 June 2005. Professor Soroosh Sorooshian acted as local host for the meeting. Drs Bin Wang and Kumar Kolli (co-chairs of AAMP) opened the session and welcomed the Panel members, invited experts, and local participants, They reminded participants of the aims of the meeting which were to "review progress in AA monsoon studies with particular focus on modelling issues, and identify research and infrstructure priorities for near future AAMP activity". A list of participants can be found at Annex A and the agreed agenda at Annex B. Dr Howard Cattle, Director of the International CLIVAR Project Office (ICPO), also extended his welcome on behalf of CLIVAR and the ICPO.

1.1 Overview of relevant WCRP/CLIVAR/SSG/ICPO activities

Dr Cattle provided an overview of CLIVAR, the World Climate Research Programme's (WCRP's) project on Climate Variability and Predictability. In doing so, he reminded the panel of the development of the new WCRP COPES (Coordinated Observation and Prediction of the Earth's Climate System) strategy which had been presented and discussed at the pan-WCRP Monsoon Modelling Workshop, held at the University of Irvine in the days just prior to AAMP-7 and which most members had attended. The call for the Workshop itself had arisen out of the deliberations of the Joint Scientific Committee (JSC) for WCRP

The aim of COPES is "to facilitate prediction of Earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society". As a strategy it aims to integrate the efforts of the core projects of WCRP (see below) and the major modelling activities under the joint JSC/CLIVAR Working Group on Coupled Modelling (WGCM) and the Working Group on Numerical Experimentation (WGNE). It will do this in particular through the establishment of pan-WCRP Task Forces. In that regard, COPES is setting specific objectives in consultation with the WCRP community. A start had been made with the WCRP COPES Task Force on Seasonal Prediction (TFSP) in which CLIVAR's Working Group on Seasonal to Interannual Prediction (WGSIP), and in particular Dr Kirtman (WGSIP co-chair), has the lead.

COPES seeks to synthesise the ongoing observational and modelling activities of all relevant WCRP components against the key concept of "seamless prediction" of the total physical climate systems from weeks to decades. To facilitate this a WCRP Modelling Panel (WMP) and a Working Group on Observations and Assimilation (now WCRP Observations and Assimilation Panel, WOAP) have been established. Further information on COPES can be found at http://copes.ipsl.jussieu.fr/index.html

CLIVAR is one of the four current projects of WCRP. The others are the Global Energy and Water Experiment (GEWEX), Climate and Cryosphere (CliC) and Stratospheric Processes and Climate (SPARC). Other WCRP activity is through the Earth System Science Partnership (ESSP) projects on the Carbon Cycle, Water, and Food and Fibre. The overall objectives of WCRP are "to determine to what extent climate can be predicted" and "the extent of human influence on climate", aiming at the goal of greatly improved understanding of the role of climate in the total Earth system. WCRP acts, through its projects, to coordinate international research effort on physical aspects of climate. It links in particular to the International Geosphere Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and Diversitas, an international programme of biodiversity science. These programmes, with WCRP, form the partners of the ESSP.

Within WCRP, CLIVAR's mission is "to observe, simulate and predict the Earth's climate system, with focus on ocean-atmosphere interactions enabling better understanding of climate variability, predictability and change, to the benefit of society and the environment in which we live". CLIVAR's science and implementation plans developed through the mid 1990s, with CLIVAR's implementation starting in earnest in 1999 following the International CLIVAR Conference held in Paris from 2-4 December 1998. Monsoons form a key focus for CLIVAR. The overall CLIVAR programme is being implemented through its panels and working groups, more detail on which can be obtained from the CLIVAR website at www.clivar.org.

CLIVAR implementation on a day to day basis is facilitated by the activities of the International CLIVAR Project Office (ICPO). Current responsibilities of ICPO staff were currently as follows (panel/working group responsibilities in brackets)

- Dr Howard Cattle (SSG, WGSIP, links to WGCM; WGCM is managed by V Satyan, Geneva)
- Dr Roberta Boscolo, working from Vigo, Spain, (Atlantic, VACS, WGOMD)
- Dr Carlos Ereno, working from Buenos Aires, Argentina (VAMOS)
- Ms Katy Hill (Pacific, GSOP)
- Dr Mike Sparrow (Southern Ocean)
- Dr Zhongwei Yan (AAMP, ETCCD, PAGES/CLIVAR)

One of the activities of the ICPO is publication of the CLIVAR Exchanges Newsletter. Printing of Exchanges is currently sponsored by the China Meteorological Administration through the Chinese Academy of Meteorological Sciences. Exchanges appears 4 times annually. Editions are frequently themed and the July 2005 edition would be focussed on the Asian Monsoon.

A major event of 2004 had been the 1st International CLIVAR Science Conference which was held in Baltimore, USA from 21-25 June. The theme of the conference had been around "understanding and predicting our climate system". AAMP members had played a key role, in particular in the session on "The Monsoon Systems", in both the plenary lectures and a wide range of submitted posters. The conference, which had 640 registered attendees from 56 countries was the largest WCRP conference ever. There were 14 major sponsors with the conference organisation being led by Dr David Legler of the US CLIVAR Office. The purposes of the conference were to review the highlights of the first 5 years of CLIVAR implementation and more importantly to determine future priorities and new directions for understanding and predicting climate. In particular it provided input into the CLIVAR self assessment which was the focus of CLIVAR SSG-13 (Baltimore, 27-29 June 2004) and which was held immediately following the conference. Dr Ed Sarachick had acted as reviewer for CLIVAR's seasonal to interannual activities (including AAMP) and Dr David Anderson (ECMWF) for modelling.

As a key outcome of the assessment, SSG-13 agreed that CLIVAR will work to focus more on the 4 major themes of ENSO, monsoons, decadal modes of variability and the thermohaline circulation and anthropogenic climate change. Workshops would be run on one of the four themes annually. SSG meetings would also be restructured with each panel and working group asked to report, in particular, against i) its contributions to the themes and annual workshops; ii) activities related to regional assessment of predictability and variability in global model outputs; iii) cross panel and working group links and iv) terms of reference (ToRs). TORs for each panel and working group were under review by the SSG and being revised to include in particular explicit reference to data management and panel and working group cross links.

From an AAMP perspective, an important decision had been the setting up of a Task Force, chaired by Bin Wang, to address in particular development of AAM linkages with GEWEX. Other members were Tetsuzo Yasunari, Wu Guoxiong, Kumar Kolli, Franco Molteni and Gary Meyers. The Task Force reviewed the AAMP focus to date and the needs for:

- Enhanced East Asian –Western North Pacific monsoon efforts.
- Coordinated General Circulation Model (GCM) and Coupled GCM (CGCM) studies
- Diagnostic Regional analysis of global datasets
- Climate change and the AAM
- Linkages between AAMP and START MAIRS.

It recommended expansion of AAMP activities and revised membership to allow greater CLIVAR/GEWEX interaction. The full science report of the Task Team can be found at Annex C.

2. Science and implementation issues

2.1 Pan-WCRP monsoon modelling

This session was aimed at reviewing the outcomes of the pan-WCRP Monsoon Modelling Workshop which, as noted above, was held just prior to the AAMP meeting itself. In particular it looked to ways to promote CLIVAR/GEWEX cooperation for AAM studies under the umbrella of WCRP and through joint efforts in developing monsoon regional climate modelling and predictions. Monsoons had been identified as one of the JSC's cross cutting issues and a summary of CLIVAR/GEWEX efforts in monsoon studies had been provided to JSC-26 (Guayaquil, Ecuador, 14-18 March 2005.

Action 1: Circulate copies of the JSC-26 paper providing an overall summary of pan-WCRP monsoon activities.

2.1.1 Summary of the outcomes of the pan-WCRP Monsoon Modelling Workshop

Dr Ken Sperber led a discussion of the outcome of the Pan-WCRP Monsoon Modelling Workshop that was held at the University of California at Irvine from 15-17 June 2005. Dr Sperber had acted as co-chair of the workshop, with Professor Tetsuzo Yasunari. At the workshop, presentations from key CLIVAR and GEWEX panels were presented to highlight the outstanding problems in modelling the Earth's monsoons. Additionally, presentations from invited experts were given to highlight important aspects of monsoon phenomena and processes, such as low-level jets, air-sea interaction, predictability, observational networks/studies, and model test beds etc. Since all persons attending the CLIVAR AAMP meeting were present for all, or most, of the monsoon workshop, a detailed description of the workshop presentations was not given. Rather, the discussion was focused on the recommendations of the workshop breakout groups and their relevance to CLIVAR AAMP.

CLIVAR AAMP endorsed the near-term workshop recommendation of investigating the diurnal cycle using a hierarchy of models a key way forward for promoting CLIVAR/GEWEX interactions. In General Circulation Model (GCM) studies CLIVAR researchers have identified the diurnal cycle as a forced "mode" of variability that is poorly represented in terms of amplitude and phase, especially in the case of precipitation. Typical phase errors of 6-12 hours are noted over both land and ocean in GCMs. CLIVAR views adequate simulation of the diurnal cycle as key aspect of variability in its own right, but also because of its potential rectification on to subseasonal variability (e.g., the Madden-Julian oscillation). It is hypothesized that improvement of diurnal variability may lead to an improved representation of intraseasonal variability and improved skill of monsoon forecasts on medium-range to seasonal time scales.

GEWEX has extensive experience in fine scale modelling (Regional Climate Models (RCMs) and Cloud Resolving Models (CRMs)) and process studies (e.g., the GEWEX Cloud System Study (GCSS)) that demonstrate a realistic representation of the diurnal cycle of precipitation is possible in regional climate models. Such results were presented at the Workshop and in the AAMP presentation of Dr Ruby Leung. She demonstrated an excellent diurnal signal in an RCM modelling study of East Asia. AAMP members and invited experts noted the importance of correctly simulating the diurnal cycle over the Maritime Continent, the Americas, and Africa. The null hypothesis is that increased horizontal resolution in global models may result in a more realistic diurnal cycle of rainfall. However, increased resolution may not be a sufficient condition to properly represent the diurnal cycle of precipitation in global models. There may be shortcomings in GCM parameterizations that have to be rectified to permit a realistic diurnal cycle. The translation of GEWEX GCSS experience in this respect will be crucial for improving global models. *(Note:Dr Mitch Moncrieff (NCAR) has demonstrated improved diurnal variability in an RCM through the addition of downdrafts in the Betts-Miller convection scheme)*. It is also noted that increased resolution may result in the simulation of tropical depressions and mesoscale convective systems that contribute significantly to seasonal mean rainfall over monsoon regions. The role of orographic forcing of rainfall was noted as an important component to be evaluated. The EOS A-train satellite observations will be essential for validation purposes, but new observational campaigns may be needed in the vicinity of steep orography.

The design of experiments to improve the diurnal cycle should occur in the next 12 months through close cooperation of CLIVAR and GEWEX. The scientific basis for such experimentation (and/or the presentation

of preliminary results) should occur as a targeted workshop that occurs in association with a pre-existing WCRP meeting. The prime candidate is the upcoming Working Group on Numerical Experimentation (WGNE) meeting on systematic error (now scheduled for February 2007). Alternative venues include the AMS hurricane/tropical meteorology conference. Prof. Peter Webster also offered Georgia Institute of Technology as a venue.

Prof. Satomura noted that he is hosting a session on diurnal variability at the August 2005 IAMAS meeting in Beijing. As such he is suggested as the contact person to spearhead the diurnal cycle investigation across the CLIVAR/GEWEX complex.

Dr Sperber was of the opinion that the adequacy of the present observing system was not sufficiently addressed at the monsoon workshop due to the workshops limited duration. For AAMP purposes, the importance of the Indian Ocean buoy system was noted as a key goal. However, the difficulty of establishing sustained observational networks in the ocean and atmosphere was noted as a limiting aspect to future progress. Prof. Julia Slingo noted the drastic difference in atmospheric reanalyses over the Asian summer monsoon domain, particularly over the Indian ocean where there has been no observed data to constrain reanalyses, as evidence for an improved observational network. Prof. Jay McCreary suggested that as was done for the Indian Ocean, OSSE-type experiments for an improved atmospheric network over southeast Asia may be needed. Dr Cattle noted that the only way forward was to develop an implementation plan and push it through existing channels for endorsement to funding agencies. Prof. McCreary noted that the Indian Ocean array will be a great leap forward when completed, though TOGA-COARE type process studies may still be needed to address specific processes (such as intraseasonal oscillation onset) over and above those obtained from routine monitoring.

Statements and actions arising from the panel discussion on the outcomes of the Workshop may be summarised as follows:

1: The panel endorsed the approach identified at the 1st pan--WCRP Monsoon Modelling Workshop (Irvine California, 15-17 June 2005) for key studies of the diurnal cycle over both land and ocean.

2: The panel also endorsed the recommendation at the Monsoon Modelling Workshop to hold a targetted workshop on diurnal variations. A member of the panel will be identified to liaise with other WCRP panels in the organisation of the workshop.

Action 2: AAMP co-chairs to identify a member of the panel will be identified to liaise with other WCRP panels in the organisation of the targeted diurnal cycle workshop

3: Noting the work of the CLIVAR/IGOOS IOP, the panel identified the need to catalogue the present long term atmospheric observing system across the AAM region as basis for identifying key stations and gaps in the network.

Action 3: ICPO to work with panel members and GEWEX to target appropriate agencies so as to realise a catalogue the present long term atmospheric observing system across the AAM region as basis for identifying key stations and gaps in the network)

4: The panel encourages and wishes to stimulate the establishment of targeted OSSEs for atmospheric observations over the AAMP region.

Action 4: Drs Webster and Hendon to consider ways to stimulate the establishment of targeted OSSEs for atmospheric observations over the AAMP region.

5:The panel also identified the need to organise a targetted observational and modelling large-scale process study aimed at ISO & onset.

Action 5: Professor Slingo and Dr Sperber to consider the organisation of a targeted observational and modelling large-scale process study aimed at ISO & onset, possibly in collaboration with GEWEX to which Dr Satumora is asked to act as a link.

6: Up- and down-scale energy transfers are a key issue for monsoon prediction. Detailed budget studies using cloud resolving models can assist to tell us what observations are needed and provide key input to observational process study experimental design. Work on this lies primarily with GEWEX.

2.2 Coordinated coupled model AAM prediction experiments

2.2.1 Review of current status of monsoon prediction with coupled models

This topic was introduced by Dr In-Sik Kang through comparisons of JJA global SST and precipitation climatologies in coupled general circulation models (CGCMs) against observed data. He demonstrated a number of common problems in state of the art CGCMs in the Pacific/AA Monsoon region, in particular:

- Cold bias in the equatorial Pacific cold tongue region
- Double ITCZ
- A cold bias over the Pacific warm pool region
- A dry bias over the equatorial Indian Ocean
- A diffuse ocean thermocline structure
- The westward shift of ENSO-related patterns

Dr Kang then gave a brief illustration of differences between tier-1 versus tier-2 prediction systems comparing correlation skill for JJA precipitation from a DEMETER 7-model ensemble for 1980-1999 (tier-1) against a WGSIP SMIP (Seasonal Model Intercomparison Project) tier-2 5-model ensemble for the same period. Particular differences for correlation skill for the the western Pacific north of the equator (higher in the tier-1 system) and the equatorial Indian Ocean regions (higher in the tier-2 system) were highlighted.

Developments at the APEC (Asian-Pacific Economic Cooperation) Climate Centre (APCC) were then outlined including its development from the APEC Climate Network (APCN). Currently the APCN has a Multi-Model Ensemble System based on the output of global climate models developed and at least partially validated in the operational seasonal-forecast mode at various institutes of several APEC member countries. The APCN will evolve into APCC during the APEC Summit meeting in Busan, Korea in November 2005 when the centre will be formally opened. This will provide a central facility that will serve as a hub for regional climate research and prediction.

2.2.2 COPES TFSP-WGSIP-AAMP interactions

Dr Ben Kirtman introduced the panel to the work of the COPES Task Force on Seasonal Prediction (TFSP) which is designing a 'seamless interactive atmosphere-ocean-land-ice prediction experiment' (see http://copes.ipsl.jussieu.fr/Organization/Activities/TFSeasonalPred.html). The TSFP had been set up by the JSC for WCRP to:

- Determine the extent to which seasonal prediction of the global climate system is possible with currently available models and data
- Identify the current limitations of the climate system model and observational data sets used to determine seasonal predictability
- Develop a coordinated plan for pan-WCRP climate system retrospective seasonal forecasting experiments.

A particular motivation for the TFSP activity lies in the potential utility of a multi-model approach of which there are several activities already underway: SMIP, APCC, DEMETER, ENSEMBLES, CTB. The key hypothesis which the TFSP experiments are designed around is the assumption that that there is currently untapped seasonal predictability due to interactions (and memory) among all the elements of the climate system (Atmosphere-Ocean-Land-Ice). The experiments were being designed to promote interactions between, and scientific leadership from, GEWEX, CLIVAR, CliC and SPARC in the area of seasonal prediction. In addition there was an awareness that seasonal predictability needs to be assessed with respect to a changing climate implying the potential inclusion of IPCC-class models in the TFSP experiments.

The experiment involves:

- Carrying out the best possible observationally based initialization of all the components of climate system
- Six month lead ensemble (10 member) fully interactive predictions of the climate system
- Predictions initialized each month of each year 1979 present
- Some predictions by some groups extended to decadal
- The use of interactive models:
  - Ocean, open but interactive (e.g., slab mixed layer or GCM)
  - Atmosphere, open but interactive, most likely a GCM
  - Land, open but interactive, e.g. SSiB, Mosaic, BATS, CLM, Bucket …
  - Ice, open but interactive (e.g., thermodynamic or dynamic).

Examples of studies which might be carried out using the outputs of the experment include:

- ENSO Mechanism Diagnostics
  - Recharge oscillator vs. delayed oscillator
  - Role of westerly wind bursts/stochastic forcing
- Impact of AO on seasonal predictability
- Regional predictability
  - Local land surface predictability
  - Extreme events
  - Monsoons
  - Diurnal cycle
- Coupled feedbacks
  - Intraseasonal variability
  - Warm ocean processes (i.e., Indian and West Pacific)

The activity was seen as more than a Model Inter-Comparison. Rather it had been conceived as a process to: facilitate total climate system predictions that are of benefit to society; the means to developing an experimental platform for coordinated hypothesis testing; the opportunity to integrate models and observations to improve predictions, models and to design observing systems and as an opportunity to directly contribute to the IPCC process in terms of evaluating and quantifying uncertainty. It was also aimed at enhancing the relevance of WCRP projects in the seasonal prediction arena, with primary project roles being as follows:

GEWEX:
- Provide guidance on how to initialize land surface
- Propose/implement diagnostic studies and numerical experiments on understanding land surface feedbacks
- Assess seasonal forecasts

CliC:
- Provide guidance on how to initialize cryosphere
- Propose/implement diagnostic studies and numerical experiments
- Assess seasonal forecasts

CLIVAR:
- Provide guidance on how to initialize ocean-atmosphere
- Propose/implement diagnostic studies and numerical experiments on understanding atmosphere-ocean coupling and variability
- Assess seasonal forecasts

SPARC:
- Provide guidance on how to prescribe atmospheric composition
- Provide guidance on how to initialize stratosphere
- Propose/implement diagnostic studies and numerical experiments
- Assess seasonal forecasts

TFSP and WGSIP are jointlycollaborating in the experiment with particular roles as follows:

- TFSP: Coordinate and Facilitate Seasonal Prediction Experiment with Pan-WCRP Perspective
    - Best possible treatment of all the elements of the climate system
    - Promote assessment of skill (potential AAMP role here)

- WGSIP: Scientific guidance, hypothesis testing, basic research (process and predictability), forecast methodology improvement, observing systems, model improvement
    - Interaction with CLIVAR Regional Panels e.g AAMP

Dr Kirtman emphasized the fact that there were already a number of coordinated activities involving model ensemble runs which AAMP might interact with. These included the SMIP (http://grads.iges.org/ellfb/SMIP2/smip.top.html), the APCN HFP pilot project (http://ces.snu.ac.kr/apcn/main.htm) and DEMETER (http://www.ecmwf.int/research/demeter/). He provided examples of a number of outputs from these. Potential areas in which studies of monsoon predictability and variability might be carried out from these or the future TFSP runs include:

- ENSO-Monsoon Interactions
    - Monsoon Predictability
        - Extreme events, variations in predictability, forecast skill, …
    - Air-sea interactions in surrounding seas
        - Role of ocean dynamics in the Western Pacific and Indian Ocean
        - Importance of coupled feedbacks
- Atmosphere-Land Interactions
    - Systematic errors
        - Model improvements
        - 1-tier vs. 2-tier prediction systems
    - Interactions with modes of variability
        - Diurnal cycle, intraseasonal variability, IOZM, PDO, AO,…
- Aerosols, land use change, changing climate

In discussion of Dr Kirtman's paper, the panel welcomed the opportunity to become involved in analysis of the TFSP experiment through regional-scale analysis relevant to AAMP interests. A small group was identified consisting of In-Sik Kang, Julia Slingo, Harry Hendon and Jay McCreary to liaise with WGSIP/TFSP on how to take interaction forward. A white paper, possibly leading to a workshop is needed for consideration by the panel. There is also a need for the development of a set of metrics aginst which to assess the outputs of the experiment.

Action 6: Kang, Slingo, Hendon and McCreary to take forward interactions with WGSIP/TFSP on AAMP's role in regional analysis of the TFSP Prediction Experiment outputs, and in particular to prepare a white paper for consideration by the panel.

Action 7: The panel to identify a range of suitable metrics relating to the AAM for application to the outputs of the TFSP Experiment (All)

2.3 Monsoon predictability and prediction

This session was aimed at the problem of determining AA monsoon predictability and at ways to quantify the skill of models for seasonal monsoon predicition. The session was introduced by Professor Julia Slingo. In her presentation, Dr Slingo demonstrated aspects of the current state of the art in monsoon prediction demonstrating a number of improvements in modelled lag/lead correlations between Niño-3 and all-India rainfall which might be brought about by use of model flux adjustments. She also noted the impact which flux adjustments and increased levels of greenhouse gases have on El Nino simulation itself. She discussed the role which the Madden Julian Oscillation has on active break cycles of the Indian summer monsoon and the ways in which these have been exploited for 20 day precipitation forecasts for the Ganges Plain (Webster et al, 2004). Overall, Dr Slingo concluded that:

- Empirical studies tell us that there is monsoon predictability on intraseasonal and interannual timescales;
- This is not realised in dynamical predictions, in part because of errors in the basic state;
- Linear bias correction may not be appropriate for coupled systems, which are non-linear;
- We still need better understanding of the complex relationships between the Indian and Pacific sectors, and between monsoon and El Niño,

She asked also whether correction techniques might be worth considering in the context of seasonal and longer-term forecasting.

In discussion, Dr Palmer challenged the implication that modern-day dynamical modelling systems using ensemble techniques were less useful in their ability to predict the monsoon that empirical techniques. He felt it worth carrying out a study on this topic. The following action was subsequently agreed:

Action 8: Carry out a comparison of (ECMWF) model and empirical (Webster) techniques against agreed metrics (Palmer/Webster)

2.4 Intraseasonal variability

This topic was introduced by Dr Peter Webster who illustrated various aspects of intraseasonal variability using sequences and composites of daily precipitation and sea surface temperature and 925 mb wind anomalies. He also demonstrated the impact that intraseasonal variability has on Indian Ocean heat transport with the intraseasonal heat flux varying between -0.5 to -4 PW in summer and +0.5 to +2.5 PW in winter. By contrast the net annual flux varies between 0 and -0.25 PW. Dr Webster also discussed the bifurcation which takes place in the Eastern Indian Ocean as opposed e.g to the Western part of the region.

In terms of a working model of intraseasonal variability, Dr Webster identified 3 phases of the ISO:

1. Destabilisation involving
    - Strong subsidence
    - Strong surface heating SST increasing
    - Upper cooling, lower heating
    - Trade Cu, Cumulus humulis mixing
    - Build up of CAPE
2. A convective phase involving:
    - Release of CAPE with deep convection
    - Projection onto equatorial modes (coupled or uncoupled??)
    - Stronger winds
    - Cooling of the ocean
3. A restoring phase involving:
    - Mode propagation
    - Stratus phase
    - Upper level heating
    - Increasing SST

Collectively, the three phase system sets the time scale of the ISO. Overall, models do not do well in simulating the phases of the ISO, nor the transitions between them.

Turning to prediction, Dr Webster emphasised that the immediacy of the need for monsoon forecasts means that we may have to adopt a pragmatic perspective. Prediction on 20-25 day timescales is the most useful for applications. He compared three approaches, emphasing the utility of the empirical schemes:

1. Coupled Ocean-Atmosphere modeling: traditional approach: experiments show that errors grow rapidly and predictability is rapidly eroded by error growth (convection?)
2. Bayesian Empirical Prediction: Conditional probability scheme provides 20-day forecasts using a banded wavelet technique. Banding “protects” longer term variability in time series from high frequency noise

3. Slow Manifold Modeling (SMM): Takes coupled ocean-atmosphere model and applies a "banding" technique allowing operational (real-time) 30-day forecasts. Early results suggest considerable skill using this method.

In terms of approaches 2 & 3, Dr Webster noted:

- Bayesian empirical modeling and SMM both forecast intraseasonal variability with considerable skill.
- For applications, the probability of an event occurring is an essential component of a forecast because it allows a cost/loss analysis to be made. More work is required to take full advantage of the Bayesian approach.
- The Bayesian model is regionally dependent and requires the creation of separate sets of predictors and regression sets for each situation (e.g., Indian monsoon and Australian monsoon will require different predictor sets)
- Currently, the Bayesian empirical scheme provides forecasts of 5-day average variability
- SMM provides 30-day daily self-consistent global forecasts which will have great use at least where the intraseasonal variability is large
- On the other hand, the empirical Bayesian modeling requires less computer resources and is more "user-friendly".
- More work is still to be done but the initial results are encouraging.

Finally, Dr Webster provided some examples of useful metrics for monsoon/ISO prediction, noting their use for model improvement and covering:

- Existing data sets (e.g., TOGA COARE, JASMINE)
- Comparisons of Wheeler-Kalidis figures between observations and models
- Composite structures of monsoon ISOs
- Predictors of empirical schemes (composite predictors and forecasts
- Behavior of predictors in numerical models versus behavior in empirical models

Papers of interest in terms of his presentation include:

Webster and Hoyos, 2004: Forecasting monsoon rain fall and river discharge variability on 20-25 day time scales.. *Bull. Amer. Meteor. Soc.* , 85 (11), 1745-1765.

Stephens, G. L., P. J. Webster, R. H. Johnson et al, 2004: Observational evidence for the mutual regulation of the tropical hydological cycle and tropical sea surface temperature. *J. Climate:* 17(11), 2213–2224.

Wang, B., P. J. Webster and H. Teng, 2005: Antecedents and Perpetuation of the Active-Break Indian Monsoon Cycles. *Geophys.Res. Lettrs*.

Agudelo, P. A., J. A. Curry, C. D. Hoyos, P. J. Webster, 2005: Transition between suppressed and active phases of convection in the Indo-Pacific warm pool intraseasonal oscillations (Submitted to *J. Clim.* May 2005)

In the discussion which followed, Dr Kang noted an email sent from the NOAA Climate Diagnostics Centre (CDC) concerning organisation of an intercomparison of intraseasonal variability. It was agreed that the panel should explore this activity, potentially with a role to organise a set of metrics for such comparisons.

Action 9: The panel to explore the CDC intraseasonal oscillation intercomparison activity, potentially with a role to organise a set of metrics for such comparisons (Wang, Kang)

Action 10: ICPO to provide a link from the AAMP webpage to the CDC intraseasonal oscillation intercomparison as and when one is in place.

2.5 Regional modelling of monsoons

In this session, Dr Ruby Lueng reviewed regional climate modelling research needs and direction. She identified the utility of regional climate modelling to be:

- ***Downscaling*** of climate variability and change at the regional scale (e.g., climate change effects on water resources, ecosystem, extreme weather; hurricane frequency; storm track; distribution of MCS and warm season precipitation; use of seasonal forecasts for water management)
- ***Process studies*** (e.g., Amazon biomass burning and aerosol effects; orographic effects; land-atmosphere interactions; ocean-atmosphere interactions; sea ice; cloud-radiation feedbacks)
- ***Upscaling*** of regional phenomena with global consequences (e.g., subtropical and tropical eastern boundary upwelling regimes; subgrid-scale clouds; organized convection; gravity wave drag)

and provided examples of MM5 rainfall simulations driven by NCEP/DoE reanalysis and AMIP SSTs for various river basins over the AAM region and an outline of regional climate model (RCM) development at NCAR using the Weather Research and Forecasting (WRF) model. Conclusions from a Workshop on Research Needs and Directions of Regional Climate Modeling Using WRF and CCSM (March 22-23, 2005) were also presented which had provided recommendations on regional Earth System modeling, high resolution modeling and upscaling research. In summary, Dr Lueng noted that:

- RCMs can reproduce some general regional climate features important for monsoon predictions (precipitation)
- RCMs provide a framework for parameterization testing
- RCMs provide a testbed for high resolution and cloud resolving modeling
- Transition to regional earth system modeling opens opportunities to investigate a wide range of climate questions and interdisciplinary studies
- Two-way GCM-RCM coupling facilitates research on scale interactions
- As with GCMs, there remain many modeling issues with RCMs, but they can play a significant role in both climate research and applications (e.g., downscaling of predictions)

In the overall discussion, the AMMP agreed the need to encourage the application of regional models to sensitivity studies of parametrization schemes relevant to monsoon prediction and to monsoon prediction per se, including application to the implications of climate change for the AAM. To assist this, an overall strategy for regional modelling for the AAM region is needed.

Action 11: R Lueng and others to consider how best to approach the development of an overall AAMP regional modelling approach.

2.6 Links to the Pacific

The aim of this session was to explore how the AAMP might enhance East Asian-Western North Pacific monsoon studies and monsoon-ENSO interactions in collaboration with CLIVAR's Pacific Panel. To help facilitate this, Dr David Neelin, who had recently joined CLIVAR's Pacific Panel reviewed a number of topics relevent to the role of the Pacific in the context of the monsoons, including the question of why the Indian Ocean is warming so rapidly (a potential cross cutting issue), ENSO-monsoon interactions and decadal variations in teleconnection patterns, the role of increased greenhouse gas concentrations for Pacific/monsoon interactions and the relevance of observational studies, including paleo-reconstructions.

In discussion, Dr McCreary noted that he was struck by the difference of issues between 2 panels. AAMP gone to shorter timescales, whereas the focus for the Pacific Panel seemed to be more on decadal timescales. He felt that the issue of ENSO-monsoon interactions was ripe for development and this could form the key basis for future collaboration between the Pacific Panel and AAMP along with the role of the MJO.

Action 12: The Panel identified ENSO-monsoon connections, including decadal variability issues including decadal variability and studies of the MJO as key areas of future interaction between AAMP and the CLIVAR Pacific Panel. This should be taken forward in the first instance by the co-chairs of AAMP and the Chair of the Pacific Panel (Dr Axel Timmermann).

Professor Bin Wang then provided a summary of the characteristics of the East Asian-Western North Pacific monsoon (EA-WNP) covering the domain of the Asian monsoon and EA-WNP subsystems, the mean annual cycle in these regions and the role of intraseasonal variability and interannual variability, noting the close association with the Australian monsoon. There are several differences between the EA-WNP monsoon and the Indian monsoon – onset dates differ; WNP monsoon rainfall is higher and peaks later (August rather than July); frontal and typhoon activity play a key role in the EA-WNP monsoon. There are strong reasons why study of the EA-WNP monsoon is appropriate as an expansion of AAMP activity: it forms a major heat source, has distinctive climatological intraseasonal oscillations with sudden changes, large interannual variability, tropical storm activity tropical/extratropical interactions as well as interactions with the Indian monsoon, ENSO and the the Pacific Decadal Oscillation and has the strongest winter monsoon. It is also challenging in modelling terms.

In agreeing the need to broaden its activity into the area of the EA-WNP monsoon, the panel felt a key area would be to encourage coupled modelling studies of the region. In particular the panel wished to encourage assessment of coupled model simulations of the EA-WNP monsoon with an initial attack on systematic model errors. This could also be another area for collaboration with the Pacific Panel.

Action 13: Bin Wang to discuss collaboration on the EA-WNP area with the Pacific Panel chair, in particular with emphasis on assessment of coupled model simulation of the EA-WNP monsoon with an initial attack on systematic model errors.

2.7 Links to the Indian Ocean Panel (IOP)

Dr Jay McCreary provided the panel with a briefing on the status of the IOP, which had been set up by the CLIVAR SSG in 2003 for an initial lifetime of 3 years as a sub-panel of AAMP, to develop an implementation plan for sustained observations in the Indian Ocean region. The panel is chaired by Dr Gary Meyers (CSIRO, Australia). The Panel had met twice in February 2004 and March 2005 and had contributed to an Indian Ocean Modelling Workshop (with AAMP) at IPRC, University of Hawaii in December 2004. The panel's report "Understanding the role of the Indian Ocean in the climate system—implementation plan for sustained observations" was in process of being finalised.

Dr McCreary outlined a number of 'science drivers' in the Indian Ocean, including the need for improved description, understanding and ability to predict:

- Seasonal monsoon variability including the. oceans role
- Intraseasonal disturbances and their interactions with the upper ocean
- Monsoon <=> ENSO interactions
- The Indian Ocean Dipole (El Niño-like phenomenon in the Indian Ocean)
- Decadal variability
- Warming trends since the 1970s.

emphasizing that unique ocean circulation systems are part of the basin-scale heat balance. In terms of the development of a sustained and integrated observing system for the region, there is a need to:

- Build a basin-scale array of upper ocean, flux and ADCP moorings
- Assess and complete the partially implemented GOOS elements—Argo, XBT, Drifters, Tide Gauges
- Coordinate development of boundary arrays
- Jointly (with tsunami community) develop a multi-hazard instrument package for moorings and coordinate ship-time.
-

Dr McCreary outlined current implementation and overall plans and issues in a number of these areas, including the role that Observing System Simulation Experiments have played in IOP planning and the panel's links with process study planning, in particular with INSTANT (2004-7), CIRENE (2007) and MISMO (2006) campaigns.

The panel had a number of plans for publishing its work, including a dedicated issue of CLIVAR Exchanges though the issue of the next available date needed clarification.

Action 14: Clarify the available date for the Indian Ocean issue of CLIVAR Exchanges (Cattle)

As noted above, the current lifetime of the IOP is limited to 3 years. The panel is seeking CLIVAR SSG agreement to continue its activities beyond 2006 and saw AAMP support as being helpful in this. There was also the issue of how the IOP should report its progress in the future as basin panels were now reporting to GSOP. There was a danger of multiple reporting routes.

Action 15: Clarify the routes and nature of reporting of IOP activities (Cattle)

Overall, the AAMP:

(a) wished to congratuate the IOP and its Chair, Dr Gary Meyers on the development of an implementation plan for a sustained Indian Ocean observing system.

(b) Strongly endorsed the IOP's request to continue its work and for the panel to have have a wider remit for development of Indian Ocean science activities than it currently has. The AAMP has no substantial objection to it acting as a separate CLIVAR ocean basin panel but would expect to have close ties with the panel on monsoon-relevant issues. The AAMP would wish to continue to receive a report from IOP at its meetings.

Action 16: IOP and AAMP chairs in liaison with the ICPO to communicate to the SSG recommending a broader science mandate for IOP.

2.8 Anthropogenic climate change

Though no explicit recommendations emerged, this session provided a review of current understanding of the AAM in response to anthropogenic forcing. The panel noted the availability of the CMIP AR4 runs for diagnostic studies in this area, which it wished to encourage. Dr Kolli's presentation on 'Climate Change and the Monsoon identified a number of key questions for the region in an ACC context include:

- How does the monsoon behave in a warmer atmosphere-ocean coupled system?
- Does more atmospheric moisture ➔ More intense hydrological cycle ➔ More intense monsoon?
- Will there be more intense/frequent ENSO anomalies ? More monsoon variability?
- Which are the sub-regions likely to be affected?
- Are land-use and land-cover changes associated with monsoon changes?
- How do we distinguish between natural and anthropogenic changes in monsoon patterns?
- Do we have global/regional policy options to deal with perceived monsoon changes?

The monsoon can change in a variety of ways, for example through changes in the spatio-temporal patterns of rainfall, the frequency of extreme seasonal anomalies, monsoon onset/withdrawal, the timing and duration of active/break periods, the frequency of severe rainstorms and in teleconnections (e.g., ENSO-Monsoon) and in its predictability. From a paleoclimatic standpoint:

- Cold periods in climatic history have winter-like circulation, whereas warm periods are characterized by a strong summer monsoon flow.
- Multidisciplinary evidence on climate during the Holocene period from the northwest regions indicate that the period between 10ka to 4.5ka BP experienced a warm and humid climate associated with relatively frequent floods.
- Around 3.5ka BP, a trend towards aridity set in over the entire northwest Indian region. However, aridity seemed to have been more active in the early part, followed by semiarid and arid conditions with present day vegetation.

- There are indications that the northern edge of the monsoon reaching the desert margins of northwest India underwent wide fluctuations leading to impermanent human civilizations to appear and disappear from the region.

Dr Kolli illustrated:

- The long term stability of the monsoon from 1810 to present.
- Regional trends in Indian summer rainfall.
- The trends in all-India surface temperatures since 1901 for the winter (0.4C/100 years), pre-monsoon (0.2C/100 years), monsoon (0.1C/100 years), post-monsoon (0.5C/100 years) and the diurnal asymmetry of the overall annual trend of 0.3C/100 years.
- Trends in sea surface temperatures over the Indian Ocean, amounting to some 0.4-0.5C/100 years

He then considered aspects of severe rainstorms over India and the changing (declining) frequency of cyclonic disturbances during the monsoon season and then discussed aspects of ENSO-monsoon relationships noting a strengthening of the ENSO-NE monsoon relationship in recent years. In terms of modelling monsoon changes, Dr Kolli noted:

- That atmosphere-ocean coupled models have made rapid strides over the past decade. Global models are relatively better in reproducing large-scale monsoon features, but problems with regional details are yet to be overcome
- Regional models provide good tools to downscale global model predictions
- High-resolution climate change scenarios for the monsoon are available for impact assessments

Dr Kolli then illustrated various examples of outputs from scenario runs for the Indian region including projected changes in ENSO-monsoon relationships. He also outlined the Joint Indo-UK Collaborative Programme on Climate Change Impacts in India: Scenario Development which is aimed at:

- Evaluation of Regional Climate Model simulations for Indian climate
- Estimation of uncertainties in model-based predictions
- Development of future climate scenarios for India during the 21st century
- Preparation of climate change scenario products for impact assessments

Collaborative work between the Indian Institute of Tropical Meteorology, Pune and the Hadley Centre (Met Office, UK) has been carried out in the framework of "**P**roviding **RE**gional **C**limates for **I**mpacts **S**tudies" (PRECIS). PRECIS is based around a high-resolution limited area model driven at its lateral and sea-surface boundaries by output from the Hadley Centre coupled models. The PRECIS model runs on a Linux PC (horizontal resolutions currently available: 50 x 50 and 25 x 25 km). It needs data for the selected domain on lateral boundary conditions (LBC) from the driving GCM (e.g., HadCM3/HadAM3) and the associated ancillary files (e.g., sea surface temperatures, vegetation, topography, etc.). The Hadley Centre has been providing the model as well as the driving data to several regional groups. Runs cover the A2 and B2 scenarios (2071-2100). Reanalysis-driven runs provide comprehensive regional data sets representing current conditions, which can assist model evaluation as well as assessment of vulnerability to current climate variability.

In terms of applications in impact assessment models, PRECIS output can be directly plugged into impact assessment models. The PRECIS model has been used with water balance models and river water routing algorithms for which the PRECIS data enables realistic representation of the processes affecting water resources, even in smaller river basins. PRECIS also generates all the required information to drive crop-weather models, to estimate impacts on agriculture. In addition, regional vegetation models like BIOME can be run with PRECIS data to estimate changes in forest cover.

In summary of his talk, Dr Kolli noted that:

- Global warming is happening NOW, with unambiguous regional signatures, and may have implications for the monsoon

- Observed data indicate that the Indian summer monsoon has been stable as a large-scale system over the past 200 years
- Most models simulate enhanced monsoon precipitation in a global warming scenario
- Large uncertainties still persist in future projections of the monsoon.
- More work needed to understand local manifestations of monsoon changes and the possible role of land-surface changes/processes
- Regional models, though useful in generating more detailed regional information, seem to inherit some of the biases seen in the driving GCMs.
- The robustness of monsoon projections based on time-slice experiments is constrained by the lack of air-sea interactions in the Indian Ocean. High-resolution coupled GCMs, at least incorporating a slab ocean model, are essential to regionalize the impact of global warming over the monsoon region.

3. Implementation of CLIVAR A-A Monsoon science plan and ways forward

Dr Cattle reviewed the past history of the panel, strting with a summary of the AAM-relevant contents of CLIVAR's Initial Implementation Plan (1998) which had identified three primary goals:

- Explore & determine the limits of predictability of the A-A monsoon climate system
- Quantify the relative contribution to monsoon predictability from the slowly varying boundary conditions & internal dynamics within the A-A minson system
- Determine the role of the monsoon on the predictability of the global climate system, in particular those related to ENSO

To contribute to the achievement of these goals, 7 specific focus areas had been identified

1. Interaction of the AA monsoon with the seasonal cycle.
2. Intraseasonal oscillations.
3. ENSO-monsoon coupling.
4. Tropospheric biennial oscillations.
5. Oceanic processes.
6. Land surface processes
7. Tropical-extratropical interactions,

to be progressed by:

- Experiments with AGCMs/OGCMs/CGCMs; surface fluxes
- Process studies including field campaigns
- Observation system requirements
- Data set & prediction system development
- Development of relevant programme linkages

The AAMP meeting of 6-7 December 1999 (Hawaii) had developed a draft document (dated April 2000) entitled "An implementation plan for CLIVAR Asian Australian Monsoon Research" with authors W Lau, S Godfrey, P Webster, T Yasumari, R Johnson, I-S Kang, R Lukas, B N Goswami, L Gates, J McBride, J McCreary, C Li, J Shukla, A Sumi, S Pu, S K Dube and contributions from: G Meyers, R Murtugudde, P Hacker, D Senegupta, M Yanai, G Meehl, S Schubert, D Waliser, J Slingo, B Wang, & M Yamanaka.

The plan saw the first step in the creation of an implementation plan for a monsoon observing system, something was now being realized for the Indian Ocean region by the activities of the IOP. Particular recommendations in the plan, many of which had also emerged during the pan-WCRP Monsoon Modelling Workshop, included:

Modelling studies:
- Continue to use AGCMs, OGCMs in stand-alone mode…
- Intercomparison experiments (with CMIP, WGSIP)

- With CMIP, use coupled models to explore mechanisms & predictability of TBO & ENSO-monsoon relationships
- Incorporate the diurnal cycle in ocean, atmosphere & coupled model simulations
- With GEWEX carry out experiments on effects of land surface processes on monsoon variability
- For validation & diagnostic analysis, develop high resolution datasets blending satellite & in-situ data; historical dataset reconstruction, unification & archiving.

Process studies
- Consider follow-ups to JASMINE & BOMEX
- Consider follow-ups to SCSMEX & studies of western Pacific warm pool.
- Conduct process studies in the E Indian Ocean off Sumatra & the W Indian Ocean to help define observational strategy to understand IO dipole
- Continue GEWEX GAME observations in Asai & maritime continent
- Continue studies of Indonesian Throughflow to determine evolution over periods of ENSO.
- Maintain close association with CEOP-1

Monsoon observing system
- Various recommendations on the Indian Ocean observing system (now taken up by IOP)
- Identify crucial sites for long term monitoring of the monsoon atmosphere
- Select the INDOEX radiation laboratory of Kishadoo (Maldives) as location of an atmospheric wind profiler.

Implementation highlights at CLIVAR SSG-12 had included:

IOOS - CLIVAR co-sponsored the IOGOOS meeting on a sustained Indian Ocean Observing System (IOOS) and (through the activities of the AAMP) has provided input to the planning documents

Argo – Deployment of floats in the Indian Ocean continues to increase. An assessment has been made of how best to deploy and utilise Argo floats in order to monitor the ocean's role in intraseasonal activity for the tropical Indian Ocean

CIMS - Development of the GEWEX CEOP (Coordinated Enhanced Observing Period) Inter-monsoon Model Study (CIMS) is ongoing with planned input from CLIVAR. CIMS will demonstrate the synergy and utility of CEOP data in climate model evaluation and improvement, particularly with respect to diurnal to intraseasonal timescales.

Simulating the MJO - A comparative analysis has been made of the representation of the Madden Julian Oscillation (MJO) in 24 AMIP-2 models and a number of coupled models. The analysis demonstrates improved simulation of the MJO when an interactive ocean is included.

Forecasting Indian Monsoon active/break cycles - A new statistical method using physically-based predictors has shown encouraging levels of skill with lead timesx of order 20 days.

Applications of AA monsoon research – The potential for applying AA monsoon research to issues of societal relevance was demonstrated.

Lessons from 2002 monsoon - An analysis has been carried out of the failure of the 2002 monsoon which was poorly forecast.

At the AAMP meeting in Atlanta, USA, (AAMP5, 25-27 February 2003), the Idea of prospectus for AAMP developed in place of finalised Implementation Plan. A version of this was finalized following AAMP-6 (Pune, India,18-20 February 2004). It can be seen at:
http://www.clivar.org/organization/aamp/publications/aampProspectusCall.pdf.

Action 17: The Panel needs to revisit the present version of the prospectus and update it in the light of the expanded remit of the panel set down by the CLIVAR AAMP Task Force(see below).

Dr Cattle concluded by reminding the panel that, as outlined in section 1.1 above, an outcome of the CLIVAR assessment at the 13th CLIVAR SSG meeting (Baltimore, USA, 27-29 June 2004), had been the setting up of a Task Force with Professor Bin Wang as chair to address, in particular, AAM linkages with GEWEX following the call for the JSC for WCRP for greater integration of WCRP monsoon activities overall. The current membership now needs to consider how best to take forward the activities of the panel through inter-sessional development of the actions from the present meeting, taking into account the outputs from the pan-WCRP Monsoon Modelling Workshop. This would ensure the panel was poised for further development of its work at its next meeting.

4. Closure of the meeting

Following review of the main action items, Professor Wang and Dr Kolli closed the meeting with particular thanks to Mrs Diane Holmbaum, secretary to Professor Soroosh Sorooshian of the University of Irvine. The panel also expressed their gratitude to Professor Sorooshian himself for the hospitality the panel had received during the period of their meeting.

Acknowledgment. Dr Sperber's work in the context of this meeting was performed under the auspices of the U.S. Department of Energy Office of Science, Climate Change Prediction Program, by University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

Annex A – List of attendees

1	Hendon	H.	hhh@bom.gov.au	BMRC Box 1289K, Melbourne Vic 3001	Australia
2	Kang	I.S.	kang@climate.snu.ac.kr	Seoul National University Dept of Atmospheric Sciences Kwanak-ku, Seoul 151	Korea
3	Kirtman	B	kirtman@cola.iges.org	Center for Ocean-Land-Atmosphere Studies 4041 Powder Mill Road Calverton MD 20705-3106	U.S.A.
4	Kumar Kolli Co-chair)	R.	kolli@tropmet.res.in	Indian Institute of Tropical Meteorology Homi Bhabha Road, Pune 411 008	India
5	Leung	R.	ruby.leung@pnl.gov	Pacific Northwest National Laboratory P.O. Box 999/K9-24 Richland, WA 99352	U.S.A.
6	McCreary	J.	jay@soest.hawaii.edu	IPRC-SOEST University of Hawaii 2525 Correa Road Honolulu HI 96822	U.S.A.
7	Neelin	J D	neelin@atmos.ucl.edu	Dept. of Atmospheric Sciences University of California, Los Angeles 405 Hilgard Ave., Los Angeles CA 90024-1565	U.S.A.
8	Satomura	T.	satomura@kugi.kyoto-u.ac.jp	Climate Physics Lab., Div. Earth and Planetary Sci. Graduate School of Science, Kyoto University Sakyo, Kyoto 606-8502,	Japan
9	Schiller	A	Andreas.Schiller@csiro.au	CSIRO	Australia
1	Slingo	J.	J.M.Slingo@reading.ac.uk	University of Reading PO Box 243 2 Earley Gate, Whiteknights Reading, Berks RG6 6BB	United Kingdom
1	Sperber	K.	Sperber1@llnl.gov	Lawrence Livermore National Laboratory PO Box 808 - L-264 Livermore, CA 94568	U.S.A.
1	Wang (Co-chair)	B.	wangbin@hawaii.edu	University of Hawaii 16380 EastWest Road Post 401 Honolulu HI 96822	U.S.A.
1	Webster	P.	pjw@eas.gatech.edu	Georgia Institute of Technology Atlanta GA 30332-0355	U.S.A.
1	Zhou	T	zhoutj@lasg.iap.ac.cn	LASG, Chinese Academy of Sciences, Beijing P.O.Box 9804, 100029	China
1	Cattle	H.	hyc@noc.soton.ac.uk	IPCO National Oceanography Centre, Southampton Empress Dock, Southampton SO14 3ZH	UK

Annex B - Meeting agenda

The 7th Session of the
CLIVAR Asian-Australian Monsoon Panel (AAMP)

18-19 June 2005
University of California, Irvine, California, USA

Meeting Aims:

To review progress in AA monsoon studies with particular focus on modelling issues, and identify research and infrastructure priorities for the near future AAMP activity.

Saturday 18 June 2005

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1. Introductions

0830-0835 Welcome and introduction of panel members and experts (Co-Chairs)
0835-0845 Discussion of agenda and perceived outcome of the meeting (led by Co-Chairs)
0845-0900 Overview on relevant WCRP/CLIVAR/SSG/ICPO activities (D/ICPO)

2. Science and implementation issues

2.1. Pan-WCRP Monsoon Modeling

To review the outcomes of the pan-WCRP Monsoon Modelling Workshop (MMW) and promote CLIVAR-GEWEX cooperation for AAM studies under the umbrella of WCRP and through joint efforts in developing monsoon regional climate modeling and predictions.

0900-0920 A summary of the outcomes of the MMW (Sperber / Satomura)
0920-1000 Discussion on the role AAMP will play in promoting and implementing the pan-WCRP monsoon modeling activities; panel actions (all, led by Sperber/Satomura)

2.2. Coordinated coupled model AAM prediction experiments

To formulate a coordinated multi-model (coupled atmosphere-ocean) monsoon seasonal prediction experiment in collaboration with CLIVAR/WGSIP.

1000-1020 A review of current knowledge of monsoon prediction with coupled models (Kang / Kirtman)
1020-1100 Discussion and actions for formulating a coordinated multi-model experiment (all, led by Kirtman/Kang)

1100-1120 Tea Break

2.3. Monsoon predictability and prediction

To determine AA monsoon predictability and quantify models' skills for seasonal monsoon prediction by diagnosing SMIP and DEMETER global datasets

1120-1140 Key speaker: Slingo
1140-1220 Discussion led by Slingo

1220-1400 Lunch

2.4. Intraseasonal Variability

To improve understanding of monsoon intraseasonal oscillation (MISO) and determine its predictability. Develop strategies for prediction of MISO in various regions of AAM.

1400-1420 Key speaker: Webster
1420-1500 Discussion led by Webster

2.5. Regional modeling and prediction of AA monsoons

To review regional climate modeling strategies for generating high-resolution monsoon prediction products and downscaling of global model predictions over AAM region.

1500-1520 Key speaker: Ruby Lueng
1520-1600 Discussion (all, led by Wang/Lueng)

1600-1630 Tea break

2.6. Links to the Pacific

To enhance East Asian-Western North Pacific monsoon studies and monsoon-ENSO interactions in collaboration with CLIVAR/Pacific panel.

1630-1700 Key speakers: Wang/Neeling/Satomura
1700-1730 Discussion - what cooperation is needed with the Pacific Panel actions etc led by Wang

1730-1800 Outstanding issues

End of Saturday sessions

Sunday 19 June 2005

2.7. Links to Indian Ocean Panel

To review IOP planning and implementation of sustained, oceanographic observations in the Indian Ocean, with regard to AA monsoon studies.

0830-0850 Key speaker: McCreary
0850-0930 Discussion led by McCreary/Webster

2.8. Anthropogenic Climate Change

To discuss current understanding of AA monsoon change in response to anthropogenic forcing, contributing to IPCC AR4 process by diagnosing CMIP datasets.

0930-1000 Key speakers: Kolli
1000-1030 Discussion - possible link to the CCl/CLIVAR Expert Team on Climate Change Detection and Indices (ETCCD), which called for input from panels about data/indices and suggestions on CCD studies, led by Kolli/Wang

1010-1030 Tea Break

3. Implementation of CLIVAR AA monsoon science plan and ways forward

1030–1100 Overview of current status from D/ICPO (Cattle)
1100-1130 Discussion - how the newly reconstituted panel should work to accomplish what targets etc, led by co-chairs

1130-1200 Action review by co-chairs

1200 End of AAMP7

Annex C – Report of the CLIVAR AAMP Task Force

Summary of the CLIVAR task force discussion

Central issue
During the CLIVAR SSG meeting in Baltimore (June 27-29 2004), it was decided to form a task force to develop a CLIVAR strategy in terms of collaborating with GEWEX in the Asian-Australian monsoon (A-AM) region. The Task force consists of Rupa Kumar Kolli, Gary Meyers, Franco Molteni, Bin Wang, Guoxiong Wu, and Tetsuzo Yasunari.

List of discussion participants
All task force members plus Valery Determmerman (WCRP), Howard Cattle and Zhongwei Yan (ICPO), Peter Webster and Julia Slingo (AAMP Co-chairs).

Summary report

1. Indian monsoon focus
AAMP has made considerable progress and has had marked success in organizing monsoon research in the Indian monsoon and Indian Ocean region. There is no doubt that the AAMP activity in the Indian Ocean should be continuously strengthened in close collaboration with IOP. The success of the AAMP in this regard has been attributed to a number of factors: The AAMP has had a concentrated effort from members from around the Indian Ocean and Japan; the AAMP has integrated the activities in this region through coordinating a variety of the national/international programs and connecting key researchers involved in those programs; and the AAMP's strong interest in oceanographic problems. These successful experiences are valuable legacies for further expansion of future AAMP activity. In setting new goals for AAMP, we need to recognize that the Indian Ocean is poorly sampled relative to the Pacific Ocean. AAMP needs to assist planning and implementation of sustained, oceanographic observations to support research on the dynamical role of the Indian Ocean in intra-seasonal climate variability and Indian Ocean zonal mode.

2. Enhancement of East Asian-Western North Pacific (EA-WNP) monsoon activity
It has been generally recognized that there is a need for AAMP to address a broader range of issues of the A-AM system. Both Indian Ocean and western North Pacific are critical components of the A-AM system. The two basins interact with each other through the monsoon system. WNP plays a critical role in driving the EA monsoon as well as the broad scale south Asian monsoon. It is suggested that the enhancement of the activity in the EA-WNP monsoon region not only facilitates collaboration with existing GEWEX efforts, but also benefits in providing a more comprehensive approach to its own TORs. Integration of the diagnostic and modeling effort in both the Indian Ocean and EA-WNP sectors and clarifying the interconnections between the monsoon variability in the two regions should be one of the priorities of research coordinated by the new AAMP. Enhancement of the EA-WNP monsoon study will benefit a more fully understanding of many important A-AM science issues such as the varying ENSO- monsoon relation, the biennial tendency of the A-AM system, the Indonesian through flow, the Indian Ocean zonal mode, and the monsoon intraseasonal oscillations. The enhancement of EA-WNP activity should help complement the ongoing regional focus in the Indian Ocean rather than shift this focus. In making a link between CLIVAR and GEWEX, it is also necessary to understand what GEWEX's interests are in the role of the ocean in the climate system.

In the EA monsoon region, there have been strong interests and a number of ongoing national and international monsoon programs including field experiments and numerical modeling studies. However, it is critical for the panel to connect the key researchers involved in those programs and form an integrated activity. In addition, key science issues need to be better identified in a unified framework of atmosphere-ocean-land interaction in this region.

The atmosphere-ocean interaction over the WNP is also one of the major sources of the variability and predictability of EA monsoon. In this context, the AAMP's connection to the Pacific Ocean panel should be reinforced.

3. Integrated regional modeling activity

Regional climate modeling studies can provide a platform for collaboration between CLIVAR and GEWEX. The regional modeling activities have been active in various A-AM regions and organized for various purposes (regional climate process studies, improvement of model physical representations, regional climate changes, and dynamical downscaling of seasonal predictions). AAMP should take advantage of the existing activities and coordinate these activities to form an integrated project by focusing on CLIVAR and GEWEX's common needs.

Considering regional climate differences and scientific interests, regional modeling studies targeting different regions may be planned in parallel. However, the panel should make sure these studies are well coordinated. From AAMP perspective, in the EA region, there is an issue concerning how to closely collaborate with post-GAME and CEOP activity; in the Indian monsoon region, a concern is how GEWEX activity will be enhanced in this area.

4. Coordinated GCM and CGCM studies

The regional modeling studies rely on the boundary conditions provided by atmospheric GCMs and coupled GCMs. In view of the difficulties of the current AGCMs and CGAMs in reproducing realistic monsoon climatology, intraseasonal variability and the amplitude and seasonal dependence of the anomalous monsoon-ENSO relation/interaction, the AAMP's effort, such as in organizing model intercomparison study of the 1997-99 ENSO cycle coordinated by In-Sink Kang, should be expanded. It has been suggested that similar studies can be coordinated by seeking a broader participation of modeling groups and by focusing on major anomalies of the A-AM variability or multi-model ensemble predictions, or intraseasonal variability. Special attention should be paid to proposing well-defined foci and developing strategies for optimal experimental designs. The successful experiences of the DEMETER project and the APCN's effort in seasonal prediction may help planning such activities. These coordinated GCM modeling activities can provide means to integrate the atmosphere-ocean interaction in both the IO and the WNP and the continental scale atmosphere-land interaction.

5. Diagnostic analysis of the global datasets at the A-AM region

As mentioned in the CLIVAR co-chair's report, CLIVAR has been particularly active in the development of multi-model climate hindcast datasets: SMIP (www-pcmdi.llnl.gov/smip) and DEMETER (www.ecmwf.int/research/demeter) for seasonal prediction and CMIP (www-pcmdi.llnl.gov/cmip) for climate change prediction. The production of these datasets presents an opportunity to develop more strongly the links between CLIVAR science on the global scale and at the regional level.

In future the AAMP should consider promoting analysis of these datasets and forthcoming available new datasets, aiming at quantifying and understanding regional predictability of seasonal climate variability or longer-term climate change in the A-AM region. Identification of the error characteristics of the current climate models in simulating regional climate variations on different timescales and enhancement of the model's predictability in the A-AM regions should be a priority item. This requires a closer collaboration between the AAMP and GEWEX/CEOP developing a unified strategy to deal with atmosphere-ocean-land interaction.

6. Prediction of monsoon intraseasonal oscillation

It has been agreed that Peter Webster's effort in predicting intraseasonal variations of monsoon rainfall is an important aspect of the monsoon studies. This effort should be developed into studies of upper ocean thermodynamics, in the Indian Ocean and EA-WNP regions and from statistical to dynamical model approach. The AAMP integrated global modeling and regional modeling projects may take this as a challenging task.

7.Climate change and the A-A Monsoons

In the context of the wide-ranging facets of the ongoing climate change debate and keeping in view the fact that more than one-half of the world's population is dependent on the A-A monsoons, it is essential that AAMP plays a more proactive role in clarifying our present understanding of the climate change impacts on the A-A Monsoons, both anthropogenic and natural. A coordinated strategy involving CGCM/AGCM/RCM experiments to bring out the sensitivity of the A-A Monsoons to greenhouse forcing, aerosols, land-use and land cover changes, etc. may be evolved. AAMP may consider the future climate change scenarios relevant to the A-A monsoons and take suitable steps to explicitly contribute to the IPCC AR4 process (Kumar, being one of the Lead Authors for WG1-Chapter 11 on Regional Climate Projections, can facilitate this

task). Taking cognizance of the gathering momentum of the IPCC AR4 activities, AAMP may have a special focus on climate change during 2005-06.

7.1 Applications and linkage with MAIRS

The long-term changes in the A-A monsoon, both in terms of mean and variability, and the associated impacts on society/ecosystems in the context of global change, is one of the cross-cutting themes within CLIVAR. It is suggested that AAMP should follow the guideline laid by AAMP6 action item on MAIRS to establish a formal linkage between AAMP and MAIRS.

International CLIVAR Project Office
National Oceanography Centre, Southampton
University of Southampton Waterfront Campus
European Way, Southampton, SO14 3ZH
United Kingdom
Tel: +44 (0) 23 8059 6777
Fax: +44 (0) 23 8059 6204
Email: icpo@noc.soton.ac.uk